

**CLAIMS:**

1           1.     A three-dimensional (3-D) integrated chip system, comprising:  
2                 a first wafer including one or more integrated circuit (IC) devices;  
3                 a second wafer including one or more integrated circuit (IC) devices; and  
4                 a metal bonding layer deposited on opposing surfaces of the first and second wafers at  
5                 designated locations to establish electrical connections between active IC devices on the first and  
6                 second wafers and to provide metal bonding between the adjacent first and second wafers, when  
7                 the first wafer is pressed against the second wafer using a flexible bladder press to account for  
8                 height differences of the metal bonding layer across the opposing surfaces of the first and second  
9                 wafers.

1           2.     The three-dimensional (3-D) integrated chip system as claimed in claim 1,  
2                 wherein the metal bonding layer includes a plurality of Copper (Cu) lines on opposing surface of  
3                 the first and second wafers to serve as electrical contacts between active IC devices on both the  
4                 first and second wafers.

1           3.     The three-dimensional (3-D) integrated chip system as claimed in claim 1,  
2                 wherein the flexible bladder press is a hollow steel container including an input valve arranged  
3                 to input air pressure, and a bottom membrane positioned over the surface of the first wafer to

1 apply the pressure differently at different points on the first wafer as the first wafer is pressed  
2 against the second wafer to account for the height differences of the metal bonding layer across  
3 the opposing surfaces of the first and second wafers.

1 4. The three-dimensional (3-D) integrated chip system as claimed in claim 1,  
2 wherein the pressure required to account for the height differences of the metal bonding layer  
3 across the opposing surfaces of the first and second wafers is determined based on the following  
4 equations:

$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

6 where " $\delta$ " indicates the total deflection on the first wafer; "L" indicates the length of the  
7 first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first  
8 wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and  
9 where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section  
10 dimension of the first wafer.

1 5. The three-dimensional (3-D) integrated chip system as claimed in claim 1,  
2 wherein the first wafer is thinner than the second wafer to conform to the height differences of  
3 the metal bonding layer across the opposing surfaces of the first and second wafers.

1           6.     The three-dimensional (3-D) integrated chip system as claimed in claim 1,  
2     wherein the flexible bladder press is an autoclave including an input valve arranged to input  
3     high-pressure gas into a chamber; a heater arranged to heat the gas at a predetermined  
4     temperature; and at least one vacuum bag arranged to contain the first and second wafers in  
5     position for metal bonding.

1           7.     The three-dimensional (3-D) integrated chip system as claimed in claim 6,  
2     wherein the vacuum bag is a flexible bag that is evacuated and then sealed to ensure that the first  
3     and second wafers are bonded, via the metal bonding layer.

1           8.     A wafer bonding method, comprising:  
2             selectively forming metallic bumps on opposing surfaces of adjacent wafers each  
3     including one or more integrated circuit (IC) devices;  
4             selectively aligning the adjacent wafers to form a stack; and  
5             bonding the metallic bumps on the surface of one wafer with the metallic bumps on the  
6     surface of the other wafer to establish electrical connections between active IC devices on the  
7     adjacent wafers using a flexible bladder press to account for height differences of the metallic  
8     bumps across the opposing surfaces of the adjacent wafers.

1           9.     The wafer bonding method as claimed in claim 8, wherein the metallic bumps are  
2     Copper (Cu) bumps deposited on opposing surface of the first and second wafers to serve as

1 electrical contacts between active IC devices on both the first and second wafers.

1 10. The wafer bonding method as claimed in claim 8, wherein the flexible bladder  
2 press is a hollow steel container including an input valve arranged to input air pressure, and a  
3 bottom membrane positioned over the surface of the first wafer to apply the pressure differently  
4 at different points on the first wafer as the first wafer is pressed against the second wafer to  
5 account for the height differences of the metallic bumps across the opposing surfaces of the first  
6 and second wafers.

1 11. The wafer bonding method as claimed in claim 8, wherein the pressure required  
2 to account for the height differences of the metallic bumps across the opposing surfaces of the  
3 first and second wafers is determined based on the following equations:

4 
$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

5 where " $\delta$ " indicates the total deflection on the first wafer; "L" indicates the length of the  
6 first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first  
7 wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and

8 where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section  
9 dimension of the first wafer.

1           12.     The wafer bonding method as claimed in claim 8, wherein the first wafer is  
2 thinner than the second wafer to conform to the height differences of the metallic bumps across  
3 the opposing surfaces of the first and second wafers.

1           13.     The wafer bonding method as claimed in claim 8, wherein the flexible bladder  
2 press is an autoclave including an input valve arranged to input high-pressure gas into a  
3 chamber; a heater arranged to heat the gas at a predetermined temperature; and at least one  
4 vacuum bag arranged to contain the first and second wafers in position for metal bonding.

1           14.     The wafer bonding method as claimed in claim 13, wherein the vacuum bag is a  
2 flexible bag that is evacuated and then sealed to ensure that the first and second wafers are  
3 bonded, via the metallic bumps.

1           15.     A three-dimensional (3-D) integrated chip system, comprising:  
2 a first wafer including one or more integrated circuit (IC) devices, and metallic bumps  
3 arranged to electrical interconnection;  
4 a second wafer including one or more integrated circuit (IC) devices, and metallic bumps  
5 arranged for electrical interconnection and with alignment with the first wafer to form a stack;  
6 and  
7 a flexible bladder press arranged to press the first wafer against the second wafer to bond  
8 the metallic bumps on the surface of the first wafer with the metallic bumps on the surface of the

1 second wafer and establish electrical connections between active IC devices on the adjacent  
2 wafers.

1 16. The three-dimensional (3-D) integrated chip system as claimed in claim 15,  
2 wherein the flexible bladder press is arranged to press the first wafer against the second wafer to  
3 account for height differences of the metallic bumps across the opposing surfaces of the first and  
4 second wafers.

1 17. The three-dimensional (3-D) integrated chip system as claimed in claim 15,  
2 wherein the flexible bladder press is a hollow steel container including an input valve arranged  
3 to input air pressure, and a bottom membrane positioned over the surface of the first wafer to  
4 apply the pressure differently at different points on the first wafer as the first wafer is pressed  
5 against the second wafer to account for the height differences of the metallic bumps across the  
6 opposing surfaces of the first and second wafers.

1 18. The three-dimensional (3-D) integrated chip system as claimed in claim 15,  
2 wherein the pressure required to account for the height differences of the metallic bumps across  
3 the opposing surfaces of the first and second wafers is determined based on the following  
4 equations:

5 
$$\delta = \frac{qL^4}{8EI}, \text{ and } I = \frac{bh^3}{3}$$

1           where " $\delta$ " indicates the total deflection on the first wafer; "L" indicates the length of the  
2           first wafer; "q" indicates the load intensity; "E" is the Young modulus of elasticity of the first  
3           wafer; and "I" indicates the moment of inertia of the rectangular cross-section; and  
4           where "h" indicates the thickness of the first wafer, and "b" indicates the cross-section  
5           dimension of the first wafer.

1           19.    The three-dimensional (3-D) integrated chip system as claimed in claim 15,  
2           wherein the first wafer is thinner than the second wafer to conform to the height differences of  
3           the metallic bumps across the opposing surfaces of the first and second wafers.

1           20.    The three-dimensional (3-D) integrated chip system as claimed in claim 15,  
2           wherein the flexible bladder press is an autoclave including an input valve arranged to input  
3           high-pressure gas into a chamber; a heater arranged to heat the gas at a predetermined  
4           temperature; and at least one vacuum bag arranged to contain the first and second wafers in  
5           position for metal bonding.